Integrating Multiple Criteria Decision Analysis into Participatory Forest Planning

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Abstract

Following the development of sustainable forest management, the focus of forest planning has shifted from being exclusively concerned with timber production to encompassing other benefits of forests as well, e.g. biodiversity and recreation. This frequently results in forest planning situations with multiple stakeholders and conflicting objectives. Tools for handling these complex situations are needed, and one such tool that has been tested is the integration of multiple criteria decision analysis (MCDA) into participatory planning.

This thesis is based upon case studies in which approaches for integrating MCDA into a participatory forest planning process were examined, by assessing both the integrated process as a whole and focusing specifically on how stakeholder values are included in the process and individual preferences are aggregated into a common preference. Key tools used in the studies were the Analytic Hierarchy Process (AHP) for eliciting preferences and the weighted arithmetic mean method (WAMM), the geometric mean method (GMM) and extended goal programming (EGP) for aggregating individual preferences.

The results show that that the integration of MCDA into participatory planning helped to structure the forest planning process in Lycksele and ensured a certain degree of transparency in the decision-making. In addition, MCDA potentially increased the substantive quality of decisions by balancing interests against each other, thereby producing solutions of higher overall stakeholder satisfaction. Stakeholders involved in the forest planning process thought in terms of specific areas when they articulated their criteria rather than in general landscape-wide objectives. Interviews and maps were used to capture these place-specific values, but further development and testing of formal approaches for handling place-specific stakeholder values are needed. The aggregation of individual preferences into a common preference was a crucial step of the participatory MCDA process. The aggregation methods tested in the studies resulted in different rankings of alternatives because of different properties. Thus, the choice of aggregation approach should be justified to avoid being arbitrary or manipulative.

Keywords: analytic hierarchy process, biodiversity, conflict management, decision making, forest management, goal programming, recreation, stakeholders

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Caminante, no hay camino,
se hace camino al andar.

(Vandrare, det finns ingen väg,
vägen blir till när du går.)

Antonio Machado

Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Nordström, E.-M., Eriksson, Ljusk O. & Öhman, K. (2010). Integrating multiple criteria decision analysis in participatory forest planning: experience from a case study in northern Sweden. *Forest Policy and Economics* 12(8), 562-574.

II Nordström, E.-M., Eriksson, Ljusk O. & Öhman K. MCDA-based participatory forest planning with consideration to general and place-specific criteria (submitted manuscript).

III Nordström, E.-M., Romero, C., Eriksson, Ljusk O. & Öhman, K. (2009). Aggregation of preferences in participatory forest planning with multiple criteria: an application to the urban forest in Lycksele, Sweden. *Canadian Journal of Forest Research* 39(10), 1979-1992.

IV Nordström, E.-M., Öhman, K. & Eriksson, Ljusk O. An experimental study of approaches for aggregating preferences in participatory forest planning (manuscript).

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Abbreviations

AHP	Analytic Hierarchy Process
EGP	Extended Goal Programming
ELP	Ecological Landscape Plan(ning)
FSC	Forest Stewardship Council
GDM	Group Decision Making
GIS	Geographic Information System
GMM	Geometric Mean Method
MCDA	Multiple Criteria Decision Analysis
PEFC	Programme for the Endorsement of Forest Certification
SFM	Sustainable Forest Management
WAMM	Weighted Arithmetic Mean Method

1 Introduction

1.1 Background

In recent decades there has been a shift of focus in forest management. The dominant orientation of forest management towards optimizing timber production, financial returns, and technical processes has gradually been replaced by a view of forests as sources of other benefits in addition to timber and profits, e.g. biodiversity and recreation (Davis *et al.*, 2001; Xu & Bengston, 1997). This changing focus is connected with the development of sustainable forest management (SFM), which takes into consideration ecological and social as well as economic values. A set of principles for SFM, the "Forest Principles", was first adopted at the United Nations Conference on Environment and Development in Rio 1992 in line with general principles of sustainable development (UN, 1992a). Following the Rio conference, several frameworks for criteria and indicators have been developed in forest policy processes to provide guidelines for evaluating and implementing SFM at the international and national level (Castañeda *et al.*, 2001). Among the most well-known frameworks for boreal and temperate forests are the Pan-European Forest (Helsinki) Process under FOREST EUROPE (the Ministerial Conference on the Protection of Forests in Europe), of which the European countries and the European Union are members (MCPFE, 2003), and the Montreal Process, of which Australia, Canada, China, Russia, and the USA are among the members (The Montréal Process, 2009). The development of SFM has also been influenced by market-driven processes of forest certification (Rametsteiner & Simula, 2003), in which the forest management practices of companies and private forest owners are assessed against certification standards including criteria for supporting economic, ecological and social values.

In the practice of SFM, the consideration of multiple values also frequently involves multiple stakeholders. In the Rio Declaration, Principle 10 concerns public participation in environmental decision making (UN, 1992b), which was further developed in the Aarhus Convention on access to information, public participation in decision making and access to justice in environmental matters (UN/ECE, 2000). In both the Pan-European Forest Process and the Montreal Process, there are also indicators referring to the need for public participation in decision making. Major reasons for undertaking public participation in SFM are (Sheppard et al., 2004; Hamersley Chambers & Beckley, 2003; FAO/ECE/ILO, 2002; Duinker, 1998):

1. to increase the overall benefit of society by considering the whole spectrum of public values, including economic, social and ecological values, and setting bounds for choices on forest management practices, strategies and policies,
2. to increase public awareness of forests and forestry and improve the social acceptance of SFM,
3. to build trust in institutions, amongst stakeholders and legitimacy for the decision making,
4. to provide a forum for managing conflicts and for learning about forest ecosystems, perspectives of other stakeholders and management alternatives, and
5. to include local and traditional knowledge in the decision making.

Inevitably, the existence of multiple objectives and multiple stakeholders results in complex, and frequently "wicked", forest planning situations (Allen & Gould, 1986; Rittel & Webber, 1973). Here, a wicked problem means a problem for which there is no single, correct formulation and the resolution of the problem will depend on the formulation used (Rittel & Webber, 1973). Each wicked problem is essentially unique and consequently there is no immediate and no ultimate test of the solution. What essentially distinguishes wicked problems from technically complex problems is the presence of subjective preferences and normative considerations; i.e. solutions to wicked problems are not true-or-false, but better-or-worse. In dealing with wicked planning problems, part of the problem is that objective information is not sufficient to solve the problem. The subjective values of stakeholders are at least as important and need to be identified and included in the planning process. Thus, the task of defining and structuring the problem is a very important part of the planning process, and these situations require a process where: (i) stakeholders are identified, (ii) criteria relevant to the situation are identified, and (iii) alternative plans are defined or developed, to be followed by phases where (iv) stakeholder preferences for criteria and alternatives are elicited, and (v) alternatives are evaluated using the preference information. In addition, this process should be flexible and, if necessary, iterative.

Tools for handling such complex forest planning situations are needed. A fundamental problem is the multiple-criteria character of these situations and the fact that the criteria are generally incommensurable; i.e. the criteria are conflicting and cannot be measured with and compared on the same scale. Basically, there are two ways of handling the incommensurability; (i) all criteria can be converted to be measured on the same scale or, alternatively, (ii) methods can be used that allow comparison of criteria despite different units and scales. For the first approach, cost-benefit analysis is frequently used for monetary valuation by comparing the expected costs to the expected benefits of a set of alternatives in order to choose the best or most profitable alternative from a societal perspective (Field, 2001). Various methods are used in cost-benefit analysis for measuring the costs and benefits depending on what kind of values these refer to. For instance, the contingent valuation method is commonly used for valuing non-market resources by asking people how much they would be willing to pay for environmental services, given a specific hypothetical scenario.

However, to convert other types of values into monetary terms may not always be feasible or appropriate (Martinez-Alier *et al.*, 1998). The alternative approach is then to use methods that enable comparison of values measured by different scales. Multiple criteria decision analysis (MCDA) encompasses a set of methods that has been developed for the application of this approach in decision making and planning situations. The advantages of using MCDA in complex participatory planning situations are: (i) it provides a formal model for the planning process that assists in making the decision making more transparent, (ii) it helps to structure the decision problem, and (iii) it incorporates subjective preferences into the decision making (Belton & Stewart, 2002; Keeney & Raiffa, 1993; von Winterfeldt & Edwards, 1986).

In the following text: (i) forestry planning processes in Sweden are identified, (ii) a frame of reference for participatory planning and MCDA in forestry is presented, (iii) a process integrating MCDA into participatory forest planning is outlined, and (iv) the objectives of this thesis are defined.

1.2 Forest planning in Sweden

Planning has been defined by Mintzberg (1994) as

> "a formalized procedure to produce an articulated result, in the form of an integrated system of decisions".

This definition distinguishes planning from the general concept of decision making by its emphasis on planning as a formalized and rational process. In addition, planning has been defined as

> " the process by which analysts perceive a problem, define it, collect data about it, formulate it (perhaps mathematically as a model), and generate and evaluate alternatives for solving it, leading to the end of the process when decision makers choose an alternative for implementation" (Cohon, 1978).

This definition is closely related to Simon's (1960) description of the three phases of rational decision making: (i) intelligence, i.e. analysis and structuring of the problem, (ii) design, i.e. development and design of potential solutions, and (iii) choice, i.e. evaluation of and choice from among alternative solutions. Thus, planning can be seen as a formal approach to conscious decision making that could comprise all activities from problem identification to implementation of the solution (Lämås, 1996). More specifically, forest planning is about making decisions regarding what treatments to apply, when and where in the forest (Öhman, 2001).

The predominant form of forest management in Sweden is even-aged management; that is, the forest is divided into stands, in which the forest is more or less homogenous and treated according to the prescriptions for each stand. The Swedish Forestry Act regulates forest management on all forest land and has specific regulations for, *inter alia*, the minimum allowable age for final felling, regeneration after felling and nature conservation (SFS 1979:429). The Swedish Environmental Code affects forest management mainly through regulations for water protection and protection of areas with high environmental value (SFS 1998:808).

In addition, forest certification also affects Swedish forest management. The most common certification standards are those of the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) (FSC, 2010; PEFC, 2006). Approximately 10.4 million hectares, half of the forest area in Sweden, is certified to the FSC standard and about 7 million hectares of forest are certified to PEFC standards (Lidestav & Berg Lejon, 2009). The certification standards have regulations for the protection of both environmental and social values. For example, criterion 4.4 of the Swedish FSC standard stipulates that

> "management planning and operations shall incorporate the results of evaluations of social impact. Consultations shall be maintained with people and

groups (both men and women) directly affected by management operations" (FSC, 2010).

The distribution of area by ownership category of the Swedish forest is ca. 50 % individual private owners, 6 % other private owners, 3 % state-owned, 14 % state-owned companies, 1 % other public ownership, and 25 % private-sector companies (Swedish Forest Agency, 2009). Forest planning takes different forms for different owner categories. Forest companies, both private-sector and state-owned, have planning processes that differ from the processes generally applied in privately and publicly owned forests.

Forest companies apply a hierarchical planning process with three main phases: 1) long-term planning, 2) medium-term planning, and 3) operational planning (Söderholm, 2002; Öhman, 2001; Weintraub & Cholaky, 1991). In the long-term planning phase, general strategies for forest management are formulated for a planning horizon of 50-100 years. The long-term planning phase forms the basis for SFM by defining the sustainable harvest level and setting general targets for nature conservation. Forest companies in Sweden use the Forest Management Planning Package, a system for inventtory, sampling and optimization, for formulating timber production strategies (Jonsson *et al.*, 1993). The nature conservation targets are identified through ecological landscape planning (ELP), in which timber production is balanced against preservation of biodiversity at the landscape level (Fries *et al.*, 1998; Törnquist, 1996). In the medium-term planning phase the general goals and strategies of the long-term planning are made concrete in the creation of a register of well-inventoried units that are to be harvested within three to five years. Field inventories are usually compiled to support the planning, and inventory results are stored in databases integrated, to varying degrees, with geographic information systems (GIS). According to the Swedish Forestry Act, the forest companies are obliged to consult with reindeer herding communities before certain specified silvicultural treatments, such as final felling of areas larger than 20 hectares, within year-round grazing areas (Swedish Forest Agency, 2010; Widmark, 2009); in these consultations the treatment of areas that will be affected within a time horizon of three to five years is discussed (Sandström & Widmark, 2007). Finally, in the operational planning phase, a detailed schedule of all forest operations is specified for periods ranging from three months to a year ahead.

The most common form of planning for private forest owners is the production of a forest management plan. A standard forest management plan is based on an inventory of the forest and contains data about the forest at stand level and general management recommendations for the individual stands. The plan usually covers a ten year period and presents treatment recommendations of varying degrees of priority for the ten years. Private forest owners' forest management plans are generally focused on timber production and creating or maintaining an even age class distribution to ensure an even harvest flow. This does not mean that forest owners may not have other goals; studies have shown that private owners are a diverse group with a range of different goals (e.g., Andersson, 2010; Hugosson & Ingemarson, 2004; Lönnstedt, 1997). Aesthetic values and recreation opportunities such as hunting and berry picking are goals that also influence the forest management. Long-term goals such as preserving and developing the forest and maintaining a tradition of forestry in the family are often important (Andersson, 2010; Lönnstedt, 1997). However, even though private owners may practice long-term forest planning, there is usually no tangible long-term plan. Nowadays, most plans are so-called "green forest management plans" because they also contain recommendations for preserving ecological value, in line with the regulation of the Forestry Act and the forest certification standards (Ingemarson, 2001). There are models for including recreational values in green forest management plans for urban areas (Eriksson, 2005), but normally the focus is on timber production and nature conservation while social values are seldom explicitly considered.

For historical reasons, most Swedish municipalities own forest, which is mostly located in or near urban areas (SLU, 2009; Lidestav, 1989). The total area amounts to approximately 1% of the Swedish forest, but because of their urban character many people live close to these areas and use them for recreation, which increases the risk of conflict over their use. For most of the municipalities, timber production is the main goal and there is a demand for a net profit yield or at least no loss from forest management, but recreation is an almost equally important goal (Lundquist, 2005). Most of the municipalities have a green forest management plan of the same kind as private forest owners (Lundquist, 2005). Many municipalities have forest management plans that incorporate recreational values into the planning, but how these values are defined is not clear. Like private forest owners, many municipalities lack long-term strategies for forest management (Lundquist, 2005; Lidestav, 1994) and use external contractors to manage their forest (Lundquist, 2005).

Thus, a conclusion is that the forest companies may need tools for incorporating social values into planning. The ELP, which is used in the companies' planning for consideration of ecological values, could be extended to include other values in a model of socioecological landscape planning (Kangas *et al.*, 2005; Hytönen *et al.*, 2002; Kangas & Store, 2002).

Socioecological planning would, like ELP, be a part of the long-term planning. Municipalities could benefit from using more structured and transparent planning processes to increase both internal control over decision making and its legitimacy. In addition, tools for supporting municipalities in long-term planning of multiple use forestry are needed. The green forest management plans cover a period of only ten years, which is not enough to provide an overview of the long-term consequences of different strategies or continuity in the planning process. Private forest owners could also be interested in more long-term, strategic forest management plans to support their long-term goals. They may be interested in multiple use forest plans to explicitly include aesthetic and recreation goals; however, such plans would primarily be aimed at satisfying the forest owner's own needs rather than social values of the public and society in general.

1.3 Theoretical frame of reference

1.3.1 Participatory planning

Participatory planning is a multidisciplinary field in itself, with roots in sociology, political science and communication studies as well as philosophy; the following section focuses on participatory planning in a forestry context. Because of its multidisciplinary character, participation is a complex phenomenon with many dimensions that has been defined in various ways. The definition adopted in this thesis is from the Ministerial Conference on the Protection of Forests in Europe that states that public participation is

> "a voluntary process whereby people, individually or through organized groups, can exchange information, express opinions and articulate interests, and have the potential to influence decisions or the outcome of the matter at hand" (FAO/ECE/ILO, 2002).

A term related to participation that occurs in the literature is group decision making (GDM), which takes place in situations where a group of people are jointly responsible for identifying a problem, structuring the problem, generating alternative solutions, evaluating the alternatives or formulating strategies for implementing the solutions (DeSanctis & Gallupe, 1987). GDM may be defined so that the group has decision making power, joint responsibility for the outcome and the members of the group negotiate about the outcome. Using this definition, participation is seldom synonymous with group decision making. In cases of GDM, individual stakeholders are involved directly or representative stakeholders have to have a strong commitment and a very clear mandate from their stakeholder groups;

furthermore, the stakeholders should be highly involved in the decision making and the power to decide should be shared, at least to some extent.

Participatory forest planning is used here in the sense of a forest planning process that involves not only the forest owners who commonly are the decision makers, but also stakeholders who have a vested interest in the planning process and the outcome of the process. These stakeholders may be representatives from governmental institutions and other organizations, such as companies and non-governmental organizations. Stakeholders may also participate in the planning process through direct public participation as individuals, e.g. local inhabitants or the general public. Three main groups of "public" stakeholders may be discerned: (i) local people, (ii) interest groups that may or may not be local, and (iii) the general public (Hamersley Chambers & Beckley, 2003). Different methods may be needed to involve these different types of stakeholders in the planning, and they may have to be involved in different stages of a planning process.

Participation may be undertaken for various reasons depending on the context of the problem and the actors involved. Three essentially different rationales have been used to describe different motivations for and perspectives on participation: the normative, substantive, and instrumental rationales (Stirling, 2008; Blackstock *et al.*, 2007; Fiorino, 1989). According to the normative rationale, participation is a way to make the decision making more democratic. Furthermore, in the normative perspective participation is an end in itself rather than a means to an end, since participation may be a process of empowerment through supporting individual and social learning. In the substantive perspective, participation is a means for producing better outcomes from a societal point of view by improving the overall understanding of the decision problem through the incorporation of multiple perspectives. Finally, the instrumental rationale is that participation may facilitate implementation and prevent conflict by improving the relations and understanding between stakeholders.

Power plays a central role in participatory processes (Buchy & Hoverman, 2000; Boon, 1999). Arnstein (1969) described participation as a redistribution of decision making power and used the 'ladder of participation' to illustrate different levels of power redistribution in society (Fig. 1). The higher up the ladder, the more power is shifted from the existing power holders to previously powerless citizens. The first two levels are simply ways to retain power under the pretence of participation, while the next three steps are merely symbolic participation in the sense that the powerless get information and an opportunity to give their opinions, but without any pledge that they will influence the decision making. According to Arnstein's definition of participation as redistribution of power to the citizens, it is only partnership, delegated power and citizen control that can be regarded as true participation.

8 Citizen control	Citizen power
7 Delegated power	
6 Partnership	
5 Placation	Tokenism
4 Consultation	
3 Informing	
2 Therapy	Nonparticipation
1 Manipulation	

Figure 1. The ladder of citizen participation (Arnstein, 1969).

Several ladders of participation, with different numbers of steps and thus different levels of detail, have been suggested as modifications of Arnstein's original ladder of participation (e.g., IAP2, 2007; Sandström & Widmark, 2007; Campbell, 1996; Berkes, 1994). The ladder of participation may be used not only for analysing participation at a theoretical level, but also as a tool for illustrating and discussing participatory processes at a more practical level (Sandström & Widmark, 2007).

So, what is good or successful participation, and how is it achieved? Evaluation or success criteria for participatory processes have been developed and proposed in a number of studies (e.g., Blackstock *et al.*, 2007; Beierle & Cayford, 2002; Germain *et al.*, 2001; Webler *et al.*, 2001; Rowe & Frewer, 2000; Chess & Purcell, 1999; Duinker, 1998). Some criteria, like "fairness", "opportunity to influence" and "transparency of process" frequently recur among the evaluation criteria (Menzel *et al.*, 2010), but the various sets of evaluation criteria are based on different perspectives, theories and contexts and hence they contain different criteria. There is no generally optimal set of criteria for evaluating the success of a participatory process. Stakeholders are likely to hold different views on the meaning of "good" or "successful" because they have different perspectives and ultimate goals in mind (e.g., Kangas *et al.*, 2010; Blackstock *et al.*, 2007; Webler *et al.*, 2001). Consequently, successful participation is a multi-dimensional concept that may imply both trade-offs and incommensurability between dimensions (Menzel *et al.*, 2010). Thus, for a thorough evaluation of a participatory process the purpose of the process should be made clear, and stakeholders may need to be involved both in defining what success means and evaluating the success of the process (Moore, 1996).

This thesis is concerned with situations where participatory planning is used to prevent future conflict rather than to handle existing conflict. Following the definition of Hallgren (2003),

> "conflict is seen as a form of interaction and is defined as social interaction through which the agents' trust to the interaction is decreasing";

that is, conflict is a condition that is detrimental to relations between stakeholders and leads to behavior that is not constructive from a conflict management perspective. Thus, this thesis is focused on how to manage situations where there are diverse and potentially conflicting interests but not an outright conflict, and takes the perspective that participatory planning and conflict management are applicable in different types of situations. In conflict situations, conflict management has to be used to establish accepted procedures and improve communication and relationships before participatory planning can be of any use for handling the subject matter in question (cf. Hallgren, 2003; Daniels & Walker, 2001). However, methods and approaches used for conflict management may also be useful in participatory planning for promoting "good" participation; two such approaches that have been developed and used in research are the consensus building approach (Innes, 1996) and the collaborative learning approach (Daniels & Walker, 2001). Consensus building is based on group deliberations in which all participants should have an equal opportunity to participate and be heard, and the process should be open to all concerns and permit the questioning of all assumptions. The aim is to develop mutual understanding of interests and agreement on facts through a fair and sound process in order to reach consensus on the decision in question (Innes, 2004; Innes, 1996). The collaborative learning approach has been developed for handling conflicts over natural resource management, and since both approaches have roots in theories of negotiation (Fischer et al., 1991) and alternative dispute resolution (Susskind & Cruikshank, 1987), collaborative learning shares some traits with consensus building. In the collaborative learning approach, however, the process itself is in focus as a way to support individual and social learning and find a way to manage conflicts, rather than a search for consensus about the outcome (Daniels & Walker, 2001).

1.3.2 Multiple criteria decision analysis

The foundations of MCDA are found in operations research as well as decision theory and welfare economics (Hwang & Yoon, 1981). Belton and Stewart (2002) described MCDA as

> "an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter".

In this perspective, adopted in this thesis, MCDA is a set of techniques that structures decision making and can be used in complex decision situations where there are different and conflicting interests. Originally developed as a tool for a single decision maker, the multi-criteria character also makes MCDA useful as a tool for participatory planning and group decision making. MCDA is mainly a tool for analysing problems of a complex nature where ordinary, unstructured decision making is insufficient to find a solution. Furthermore, since MCDA supports exploration and structuring of the decision problem and includes subjective preferences into the decision making it may be used as tool for managing wicked problems.

MCDA techniques are mathematical methods that make it possible to optimize decisions for multiple objectives based on the preferences of the decision maker, and they provide a formalized procedure for decision analysis that supports the structuring and exploration of problems. This process can be described in four steps (Belton & Stewart, 2002; Malczewski, 1999; Keeney, 1982):

1. Structure the decision problem, i.e. specify objectives. An objective can be defined as a statement of something that one wants to achieve (Keeney, 1992; Starr & Zeleny, 1977). Moreover, objectives have a preferential direction; that is, they are either of the "more is better" or "less is better" kind. The objectives describe the decision problem and can be structured in an objective hierarchy, a tree-like structure where criteria are organized according to how they relate to each other.
2. Generate alternatives and assess possible impacts of each alternative. *Alternatives* are the means for achieving the stated objectives, i.e. plans, strategies, items of choice, actions, etc., which are to be evaluated (Zeleny, 1982; Starr & Zeleny, 1977). *Attributes* describes characteristics of the alternatives; i.e. one or more attributes are used to measure how well an alternative performs in terms of a certain objective (Keeney, 1992; Starr & Zeleny, 1977). *Criterion* is a general term that includes both objectives and attributes (Malczewski, 1999; Starr & Zeleny, 1977).
3. Elicit preference values from decision makers. *Preferences* are subjective judgments made by the decision maker(s) on the importance of a criterion or an alternative.
4. Evaluate and compare alternatives.

These steps are related to Simon's (1960) three phases of decision making (Fig. 2) (Malczewski, 1999). The different MCDA techniques are mainly characterized by the way they handle steps 2-4, and much focus has been placed on these steps (Belton & Stewart, 2002). However, in real world problems the structure of the decision problem is seldom given or obvious, and the need for attention to this step has been increasingly recognized (Mendoza & Martins, 2006; Tikkanen *et al.*, 2006; Mendoza & Prabhu, 2005; Hjortso, 2004).

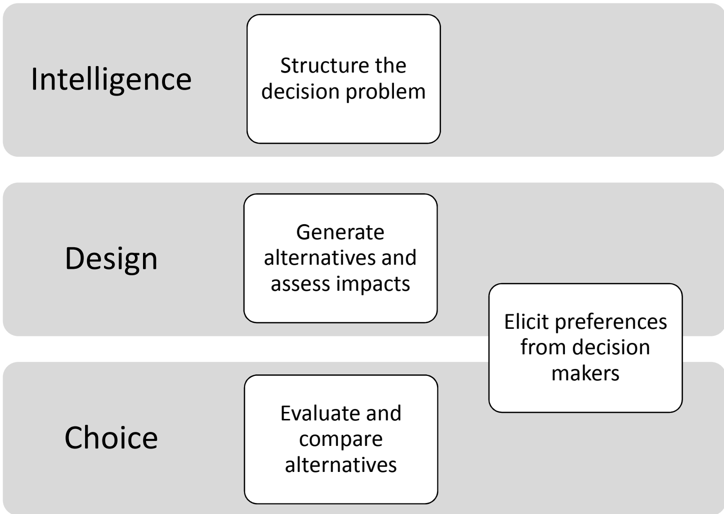

Figure 2. The four steps of the formalized structure of MCDA related to Simon's (1960) three phases of decision making (adapted from Malczewski, 1999).

MCDA techniques have been classified in a number of ways depending on the perspective and purpose of the classification. Belton and Stewart (2002) classified MCDA techniques into three different categories, based on the way the preferences are modelled. The categories are: (i) goal, aspiration or reference level techniques, (ii) outranking techniques, and (iii) value measurement techniques.

In goal, aspiration or reference level techniques preferences are stated by setting goal levels for each criterion so that the levels reflect the requirements of the decision maker. The goal level can either represent a required minimum or maximum level, or a desirable level for which the aspiration is to achieve it as closely as possible. The goal levels can also have varying degrees of achievability, ranging from an absolutely lowest level to very optimistic visions. The criteria should normally be quantifiable on a cardinal scale; i.e. it should be possible to compare the values and differences between values. If the criteria are qualitative and cannot be quantified, the goal level techniques could be used to give an overview of alternatives and help select a subset of alternatives. When goal levels are set, different methods can be used to search for alternatives through which the goals can be fulfilled to the greatest possible extent. In practice, this is mostly a case of identifying alternatives that minimize the underachievement of the goals, since decision problems where an optimal solution for all criteria can be found are rare. Thus, usually there are several trade-offs to consider in the alternative solutions. According to Mendoza and Martins (2006), goal level techniques seem to be used to approximately the same extent as value measurement models. Examples of goal level techniques are different varieties of goal programming, multi-objective programming, and compromise programming (Romero & Rehman, 2003).

The principle behind outranking techniques is pairwise comparison between alternatives. The first step is to evaluate each alternative in terms of each criterion; this is done using either an ordinal or cardinal scale, which can be subjectively defined. A decision matrix of alternatives and criteria is then created, and the criteria are given weights that can be regarded as votes for the importance of each criterion. The next step is to use these data to compare the alternatives pairwise and evaluate the relative preferences for the alternatives. This can be done by defining thresholds for indifference and preference for one alternative over another or by defining the intensity of preference on a scale. The result of the pairwise comparison is either that one alternative outranks the other, i.e. it is strictly preferred to the other; or indifference, i.e. that neither alternative is preferred over the other; or incomparability, i.e. it is not possible to determine the preference relationship between the alternatives with the available information. The final step is to find out if there is an alternative that outranks the others overall, either by being as good as or better than the others, supported by a certain weight of criteria, or by being very strongly preferred in terms of one or more criteria. The rules for this procedure differ between the models. The most well known outranking techniques are those of the ELECTRE (I-IV, TRI, IS)(Roy, 1991) and PROMETHEE (I-VI)(Brans & Vincke, 1985) groups. Outranking techniques have not been used as frequently in natural resource management studies as goal level or value measurement techniques (Mendoza & Martins, 2006).

The basis of value measurement techniques is to generate a preference order of a set of alternatives by constructing a value function. Initially, so-called partial value functions are generated for each criterion; the preference order of alternatives is given in terms of every criterion. The criteria are then weighted and the weighted partial value functions are aggregated into a value function for the alternatives. All alternatives must have a consistent position in the preference order given by the value function; the relationship between the alternatives can be that either one alternative is preferred to another or that both alternatives are equally preferred, i.e. there is indifference between them. Probabilities and statistical expectations can be used to introduce uncertainty as part of the preference modeling. Value measurement is a common approach in the field of MCDA (Mendoza & Martins, 2006); examples of applied techniques are the Simple Multi-Attribute Rating Technique (SMART) (von Winterfeldt & Edwards, 1986), the Stochastic Multicriteria Acceptability Analysis methods (SMAA) (Lahdelma *et al.*, 1998), and Multicriteria Approval voting (MA) (Fraser & Hauge, 1998). Utility functions are often used under the name Multi Attribute Utility Theory (MAUT), and the value function approach is similarly occasionally called Multi Attribute Value Theory (MAVT) (Keeney & Raiffa, 1993; von Winterfeldt & Edwards, 1986).

One of the most well known value measurement techniques is the Analytic Hierarchy Process (AHP) (Saaty, 1990), which has been applied in a number of forest planning cases during the past twenty years (Ananda & Herath, 2009; Diaz-Balteiro & Romero, 2008). The AHP technique was also used to elicit preferences in the studies this thesis is based upon, hence this method will be described in more detail here. The AHP technique is characterized by a procedure of pairwise comparisons of criteria and alternatives where a nine-point scale is used to measure preferences. The standard AHP technique consists of the following four steps (adapted from (Saaty, 1994)):

1. *Structuring the decision situation as a hierarchy:* The starting point for AHP is the construction of an objective hierarchy, describing the relations between the criteria describing the decision problem.
2. *Eliciting preferences for objectives and alternatives:* The objective hierarchy is used for eliciting judgements concerning criteria and alternatives from the decision maker in a structured way. This procedure is done by systematic, pairwise comparison of the criteria, until all criteria on the same level and belonging to the same branch of the hierarchy have been compared. The alternatives are also compared pairwise with respect to each of the lowest-level criteria at a time to evaluate to what extent one alternative is preferred over another in terms of the criterion in question. All the comparisons are made using a nine-point ratio scale to determine the strength of preference for one criterion or alternative over another

(Tab. 1). The comparisons can be organized in an *n* x *n* matrix, where $a_{i,j}$ is the numerical rating of the preference strength of criterion *i* over criterion *j* (or alternative *i* over alternative *j*) and corresponds to the ratio of the weight w_i of criterion *i* to the weight w_j of criterion *j*.

$$A = [a_{ij}] = \begin{bmatrix} 1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & 1 & \dots & w_2/w_n \\ \dots & \dots & 1 & \dots \\ w_n/w_1 & w_n/w_2 & \dots & 1 \end{bmatrix}$$

If criterion *j* is preferred over criterion *i*, the correlating reciprocal number is entered. Only the comparison $a_{i,j}$ is made, since $a_{j,i}$ is assumed to be 1/ $a_{i,j}$. Every objective compared with itself results in the value 1, that is $a_{i,j}$ = 1 when *i* = *j*.

Table 1. *A summary of Saaty's nine-point ratio scale (Saaty, 1977)*

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed

3. *Calculating the weights of the criteria and the alternatives:* In standard AHP, the weights, w, of the criteria and alternatives are calculated by finding the eigenvector w that corresponds to the maximum eigenvalue, λ_{max}, for each comparison matrix: Aw = λ_{max} w. The weights are normalized to sum to 1. The eigenvector method takes account of the fact that the judgements in the pairwise comparisons might be inconsistent because of uncertainty or error and λ_{max} can be used to measure the consistency of the judgements. The most commonly used measure of consistency is the consistency ratio (CR) (see Saaty, 1990).
4. *Synthesizing the weights to establish an overall ranking of alternatives:* The overall weight for an alternative is calculated by multiplying the criterion

weight with the weight for the alternative with respect to the criterion in question. This is done for all criteria; the resulting products are summed to produce the overall weight for the alternative. The alternatives can then be ranked according to the weights.

The three categories of MCDA techniques are suitable in different situations, depending on the kind of preference information available and the nature of the decision problem to be solved. Because of their mathematical programming character, goal level techniques are very useful in decision situations where the number of potential solutions is very large. These techniques are also able to handle a relatively large number of criteria. The goal level techniques can be used in a process to generate a subset of feasible alternatives, but may be inappropriate to use for making the final decision due to the lack of transparency. Goal level techniques can also be used iteratively by letting the decision maker refine goals during the course of the process. The outranking techniques are designed for use in situations where one alternative is to be selected from a limited set of discrete alternatives. The indifference and preference thresholds and the way the preference order of the alternatives works make the preference modelling of the outranking techniques realistic and quite similar to the cognitive process of a human decision maker. However, concepts like the indifference and preference thresholds are rather intricate and may make the techniques less transparent. This implies that outranking techniques may be problematic in participatory situations when understanding of and learning from the decision process is desired (Kangas *et al.*, 2001a). The value measurement techniques are relatively transparent and may be more valuable for gaining insight into the decision process and the preferences of the decision maker than for identifying a precise, optimal solution. Such situations can be found when individual and social learning is an important part of the process. Value measurement techniques can be used both in relatively simple, phased decision processes and in iterative processes where a first, orienting round is followed by a more informed process.

In addition to categorizing MCDA techniques based on the way the preferences are modelled, MCDA techniques can also be categorized as compensatory or non-compensatory techniques (Hwang & Yoon, 1981); this categorization cuts across the three categories of value measurement, goal level, and outranking techniques. Compensatory techniques allow for trade-offs between criteria; e.g. a decreased score for one criterion may be compensated for by an increased score for another criterion. When a non-compensatory technique is used, a high score for one criterion does not compensate for a low score for another. Thus, value measurement techniques are compensatory because trade-offs between criteria can be defined, while, e.g., lexicographic goal programming is non-compensatory or only partly compensatory. These properties may be useful in different situations; for instance, in situations with more than one decision maker the criteria weights may reflect the importance of the criteria rather than acceptable trade-offs and non-compensatory techniques may be more appropriate (Munda, 2004).

MCDA techniques can also be categorized more generally into multi-attribute decision analysis (MADA) and multi-objective decision analysis (MODA) techniques (Malczewski, 1999; Hwang & Yoon, 1981). In MADA techniques, the focus is on the attributes and the alternatives that the attributes evaluate. There is a limited, discrete set of alternatives and the decision situation can be characterized as a choice problem, where the task is to identify the most appropriate alternative. In contrast, in the other variety of MCDA techniques, MODA, the focus is on the objectives and there is a very large number of possible alternatives. Thus, a typical MODA problem is continuous and the problem is to design one or several appropriate solutions rather than to choose from a defined set, as in MADA.

1.3.3 The participatory MCDA process

In the forestry context, approaches combining participatory planning and MCDA are relatively new (Diaz-Balteiro & Romero, 2008); most studies of participatory forest planning in combination with MCDA techniques have been published during the last decade (Hiltunen *et al.*, 2009; Hiltunen *et al.*, 2008; Pykäläinen *et al.*, 2007; Sheppard & Meitner, 2005; Laukkanen *et al.*, 2004; Maness & Farrell, 2004; Ananda & Herath, 2003a; Ananda & Herath, 2003b; Kangas *et al.*, 2001a; Pykäläinen *et al.*, 1999; Kangas *et al.*, 1996).

Using MCDA in participatory planning provides a structured way of working that generates knowledge about the problem and the objectives of the different stakeholders (Mendoza & Martins, 2006). Furthermore, MCDA can support a participatory process by making it transparent, fair, and understandable, all of which are important properties for the process to be considered legitimate and accepted by the stakeholders. Transparency means that it is possible to account for the outcome of the process in terms of the input and the mechanisms of the MCDA technique, because the MCDA process is well structured (Rauschmayer & Wittmer, 2006). Fairness has to do with the power relations between stakeholders and how power differences are handled in the process (Phillips, 1997). With MCDA, the influence of different stakeholders on the outcome can be made explicit in the aggregation of preferences.

A challenge associated with combining MCDA and participatory planning is the interdisciplinary and applied character of the work (Munda, 2004). Despite this, studies tend to focus on the numerical properties of MCDA techniques, no doubt because studies including MCDA are highly specialized and require expert knowledge. Thus, there could be a need for more focus on the participatory aspect of the studies and for analyses that show how MCDA is actually integrated in the participatory process. This would mean a shift from the view of MCDA as providing technical methods for problem solving to the view of MCDA as providing methods for problem structuring (Mendoza & Martins, 2006).

The work underlying this thesis is concerned with a model of a process where MCDA is integrated in a participatory forest planning process. This participatory MCDA process is modeled for situations where MADA techniques are used and comprises the following stages: stakeholder analysis, structuring of the decision problem, generation of alternatives, elicitation of preferences, and ranking of alternatives (Fig. 3).

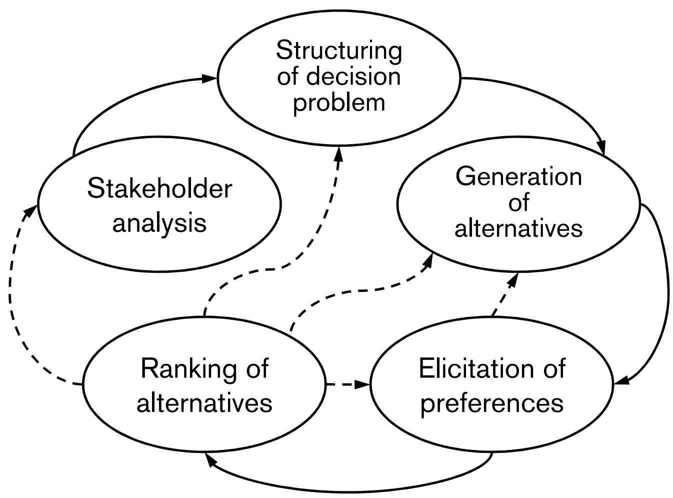

Figure 3. A general model for a participatory MCDA process; the continuous lines shows how the five stages are interconnected and the dashed lines indicate how the process may be iterated if information from a previous stage is incomplete.

Stakeholder analysis

The objectives of stakeholder analysis are to identify all relevant stakeholders and to determine the extent of their participation. *Stakeholder* means someone who is affected by or can affect the situation in some way; that is, the stakeholders have vested interests in the decision problem (Banville *et al.*, 1998; Grimble & Wellard, 1997).

A thorough stakeholder analysis is critical at the beginning of a participatory process. If important stakeholders are left out of the process, central questions might be ignored, and consequently the overall picture of the situation will be incomplete. Ultimately, this can mean that the solution found through the process will not be a solution to the real problem. Furthermore, a process where central stakeholders are left out is not likely to be accepted as a participatory process, and implementation might be impaired. The relationship among the participants in terms of how power, as in control over resources and decision making, is distributed should be made clear; e.g. by using the ladder of participation.

Structuring of the decision problem

The aim of this step is to define the decision problem by identifying and structuring the stakeholders' objectives and attributes. When using MCDA, the structuring of a decision problem will influence the outcome, since the problems are mostly wicked, or at least so complex that the task is not only a matter of solving a problem but also of defining what the problem is (Rittel & Webber, 1973; Simon, 1960).

Thus, in a participatory MCDA process stakeholders should be included in the identification of criteria, to ensure that the definition of the problem includes aspects important to stakeholders and all relevant objectives. This has been done in a number of studies of MCDA in participatory forest planning (e.g., Hiltunen *et al.*, 2008; Pykäläinen *et al.*, 2007; Sheppard & Meitner, 2005; Laukkanen *et al.*, 2004; Kangas *et al.*, 1996), although in far from all studies.

Furthermore, forest planning is a special case of land-use planning where spatial aspects are important (Öhman, 2001). In SFM, spatiality has to be considered for economic, ecological and social reasons. Experience from participatory forest planning indicates that there are different types of values, and that stakeholders may think about the forest in terms of certain specific areas rather than in general forest-wide terms (Nordström *et al.*, 2010; Saarikoski *et al.*, 2010; Kangas *et al.*, 2008; Aasetre, 2006; Cheng & Mattor, 2006; Hytönen *et al.*, 2002; Williams & Stewart, 1998). In case studies combining MCDA and participatory forest planning, criteria are often expressed in a general forest-wide way which may frustrate stakeholders because they cannot express their values in natural way (Kangas *et al.*, 2008).

To capture place-specific values, maps are needed when stakeholders are expressing their criteria.

Commonly, stakeholders have been involved in the identification of criteria, but criteria are sometimes defined exclusively by experts, analysts, or are based on an existing criteria and indicator framework (Maness & Farrell, 2004; Pykäläinen *et al.*, 1999); in a few cases, it is unclear how criteria were identified (Ananda, 2007; Kangas *et al.*, 2005; Kangas *et al.*, 2001a). In most cases in which stakeholders have been involved, criteria have been identified collectively through discussions, either in groups of stakeholders with similar interests or with all stakeholders together.

Generation of alternatives

The way in which alternatives are generated, and their nature, are both critical to the outcome of the process, because if alternatives cannot be modified or new ones cannot be added during the process the choice is confined to the given alternatives. Often, an iterative process in which alternatives are refined according to stakeholders' preferences would be desirable (see, e.g., Castelletti & Soncini-Sessa, 2006), but time and resources constraints can make this unfeasible. Thus, alternatives must be generated carefully; they must be nondominated, realistic, and not too extremely directed toward any single stakeholder's interests, but at the same time they must span the objective space sufficiently (Hiltunen *et al.*, 2009). Place-specific values identified by stakeholders should be considered in the generation of alternatives. Depending on how the alternatives are to be evaluated, the number of alternatives is also important; too many alternatives can make the evaluation by stakeholders too demanding, rendering the final result unreliable.

Forest planning problems are often of a MODA character because a relatively large number of forest stands are assigned different treatments at different points in time and thus the number of possible solutions is usually large (Andrienko *et al.*, 2007). Despite this, in most case studies combining MCDA and participatory forest planning the MADA approach has been applied; two exceptions are the studies by Kangas *et al.* (1996) and Maness and Farrell (2004). When a MODA problem such as forest planning is addressed by a MADA approach, the problem is transformed from being a matter of designing alternatives to a matter of choosing from a defined set of discrete alternatives. In the context of participatory planning, the question of how these alternatives are defined is important because the decision space is restricted and if stakeholders have not been given the chance to influence the definition of alternatives they have been excluded from a crucial part of the decision making process (Hiltunen *et al.*, 2009). In a case of regional strategic forest planning in Finland, Hiltunen *et al.* (2008) concluded that a number of three to five alternative plans, covering the major outlines of the plans rather than minor variations, seems to be appropriate. Some existing case studies describe the generation of alternatives (Hiltunen *et al.*, 2008; Pykäläinen *et al.*, 2007; Kangas *et al.*, 2005; Sheppard & Meitner, 2005), but detailed information on how alternatives were produced, and if place-specific values were included, is generally sparse.

Elicitation of preferences

Varying modes of expression can be used when stakeholders state their preferences: in a group or individually, at a personal meeting or by a form, on one occasion or iteratively. The choice of mode and MCDA technique must depend on the situation and the stakeholders (Kangas & Kangas, 2005; Belton & Stewart, 2002). In cases where more complex MCDA techniques are used, a personal meeting with the possibility of adjusting preferences as knowledge of the situation increases would be a desirable working mode (Kangas and Kangas, 2005). In situations with many stakeholders, and where actual meetings are difficult because of geographical distance or lack of time, preferences may have to be elicited through inquiry forms or Internet-based, user-friendly decision support systems (Kangas & Store, 2003).

AHP is one of the most frequently used MCDA techniques in forest planning (Ananda & Herath, 2009; Diaz-Balteiro & Romero, 2008). The properties of AHP make it possible to combine objective information with subjective preferences as well as incorporating both qualitative and quantitative criteria, which could make it useful in participatory planning (Kangas & Kangas, 2005). Furthermore, with the pairwise comparison procedure used in AHP, the decision maker focuses on the trade-off between two criteria or alternatives at a time, which may improve the decision maker's understanding of the problem (Hajkowicz *et al.*, 2000). However, when using standard AHP in which pairwise comparisons of all criteria and alternatives are made, the number of criteria and alternatives is critical as the number of comparisons increases rapidly with increases in the number of criteria and alternatives. For instance, Saaty and Ozdemir (2003) recommended that pairwise comparisons should not be made for more than 7 (±2) elements at the same level in order to avoid confusion and inconsistency.

Ranking of alternatives

In the final step, preferences in the form of weights for criteria and alternatives are combined by some kind of decision rule resulting in overall weights that make it possible to rank the alternatives in a preference order. The decision rule is defined by the specific MCDA technique used (Malczewski, 1999).

When MCDA is used in a participatory process, some kind of aggregation of individual preferences into a common preference is required to obtain an overall outcome. Belton and Pictet (1997) have defined three general procedures for achieving a group decision: (i) sharing – the group can act as a single decision maker and agree on one common preference; (ii) aggregating – the stakeholders can state their individual preferences and a common preference is obtained through voting or calculation; and (iii) comparing – the stakeholders state their individual preferences and these are used in a negotiation process in which the aim is to find a consensus solution. In the procedures for sharing and comparing, a consensus is sought via discussions and negotiations. When aggregation is used, deliberations among stakeholders are to some extent replaced by a mathematical method for computing consensus solutions. In most studies combining MCDA and participatory forest planning, the overall results have been calculated through aggregation in this sense of the word (e.g., Ananda, 2007; Pykäläinen *et al.*, 2007; Kangas *et al.*, 2001a; Kangas *et al.*, 1996). However, aggregation of preferences in number form may feel mechanistic to stakeholders. Thus, the results should be supplemented by sensitivity analysis and discussion of the weights of influence for the stakeholders. Furthermore, for higher levels of participation, all stakeholders should be involved in determining the weights of influence and possibly in the choice of aggregation method.

1.4 Objectives of the thesis

The main objective of this thesis is to investigate approaches for integrating MCDA into a participatory forest planning process. This includes an overall analysis and assessment of the participatory process as a whole, and specific attention to the identification and incorporation of stakeholder values into the process and the procedure for aggregating individual preferences into a common preference (Fig. 4). The thesis is based on case studies of an actual participatory planning process in the municipality of Lycksele, Sweden (Papers I, II, and III), and a simulated planning process based on forest data from Lycksele involving forestry students at the Swedish University of

Agricultural Sciences (Paper IV). All papers are based on forest data from Lycksele. Papers I, II, and III use preference data from the real world participatory planning process in Lycksele, whereas for paper IV methods were utilized that were not used in the real world process.

The thesis adopts a forest planning approach to the problem of integrating MCDA into participatory planning, through exploring the applicability of the integrated process to forest planning situations. In addition, the work is aimed at planning processes in contexts similar to that of Swedish forestry, where commercial timber production is a major land use, and ownership and user rights are clearly regulated.

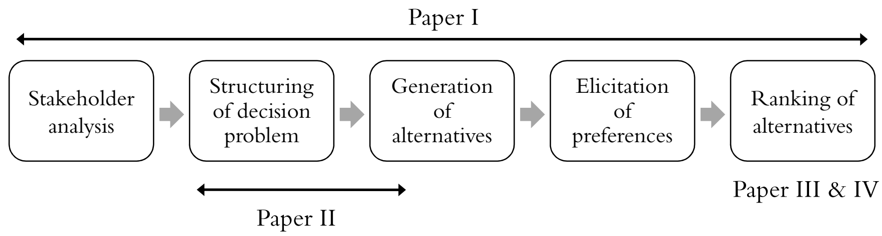

Figure 4. A schematic view showing which steps of the participatory MCDA process the papers included in this thesis deal with.

The specific objectives of Papers I-IV were:

Paper I: To analyze strengths and weaknesses of the integrated process based on results from a case study of a planning process in Lycksele, northern Sweden. The analysis was supplemented by an assessment of the participatory process with a focus on how the use of MCDA influenced the process.

Paper II: To present an approach for including place-specific values in MCDA-based participatory forest planning. The approach was applied in the Lycksele case study where MCDA was integrated into a participatory process for choosing a multi-purpose forest plan for the urban forest.

Paper III: To adapt an existing aggregation method based on the determination of cardinal compromise consensus to the case of participatory forest planning in Lycksele. Possible consensus solutions for choice of forest management plan were explored and the usefulness of the aggregation method for participatory forest planning problems was evaluated.

Paper IV: To evaluate the results and properties of three approaches to the aggregation of individual stakeholder preferences into a common preference in participatory forest planning using MCDA. The aggregation approaches tested were extended goal programming (EGP), the weighted arithmetic mean method (WAMM), and the geometric mean method

(GMM), using a group preference approach as a reference for comparison. The approaches were based on data from a role-playing exercise with students.

2 Summary of papers

2.1 Integrating multiple criteria decision analysis in participatory forest planning: experience from a case study in northern Sweden (Paper I)

The aim of this study was to analyze the strengths and weaknesses of a participatory MCDA process, focusing on how the use of MCDA influenced the participatory process. A model for a participatory MCDA process with five steps was outlined: stakeholder analysis, structuring of the decision problem, generation of alternatives, eliciting preferences and ranking of alternatives using AHP. This model was applied in a case study of a planning process for the urban forest in Lycksele, Sweden. An assessment was made of the participatory process with a focus on how the use of MCDA had influenced the process.

Lycksele is a municipality in the county of Västerbotten in northern Sweden which covers an area of 5 636 km² and has approximately 12 000 inhabitants (Fig. 5). Lycksele is also the name of the main town of the municipality. The town Lycksele is the regional center in a forest landscape area where commercial forestry is an important industry for the local economy. However, the forest is important to the inhabitants of the town for purposes other than timber production, e.g. for the reindeer herding industry, for preserving biodiversity, and for recreation, hunting, and fishing opportunities. These seemingly incompatible interests in the forest are a potential source of conflict. The planning situation is further complicated by the fact that the urban forest is owned not only by the municipality but also by commercial forest companies, the Church of Sweden, and private landowners.

To create a comprehensive overview of forest use and management around the town of Lycksele, the municipality initiated a project with the aim of producing a multiple-use forest management plan. The plan was to be a strategic forest management plan including both timber production and other uses of the forest. The interests involved motivated a long range perspective, in this case 100 years. The plan was to cover a total area around the town of 8 637 ha of productive forest divided into 980 forest stands, of which 11 % were municipal forest, 84 % forest belonging to three forest companies and the Church of Sweden, and the other ca. 5 % forest owned by nonindustrial private forest owners. The authors of this paper were charged with the task of designing and leading the planning process.

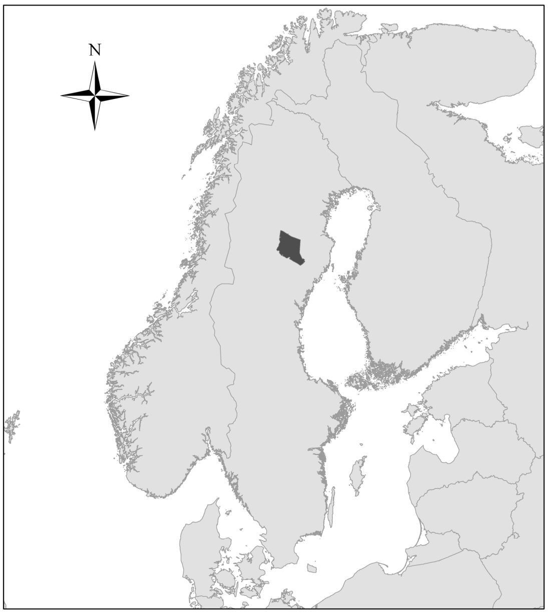

Figure 5. Map of Sweden, showing Lycksele municipality (shaded area).

The process started with a meeting of the steering group for the planning process; i.e. representatives from the three forest-owning companies, the Church of Sweden, the municipality, the Forest Agency, and the County Board – and two of the authors of Paper I. The steering group identified potential stakeholders and discussed appropriate levels of participation for stakeholders in the planning process, using a ladder of participation with five rungs. This resulted in a model in which forest owners were to retain the decision making power, while representatives of nature conservation, outdoor activity, tourism and education interest groups, and the reindeer herding industry, were placed on the involvement level (level 3). The general public was placed on the consultation level (level 2) (Tab. 2).

Table 2. *The ladder of participation used in the Lycksele planning process: The International Association for Public Participation's spectrum of public participation (© 2007 International Association for Public Participation, www.iap2.org)*

Level	Stakeholders
5 Empower	
4 Collaborate	
3 Involve	Nature conservation, outdoor activities, tourism, education, reindeer herding industry
2 Consult	General public
1 Inform	

Thus, this first meeting formed the basis for a stakeholder analysis. The list of identified stakeholders was refined to a list of selected people of whom the majority were members of an existing network used by the municipality ecologist as a reference group in forestry-related issues. The selected stakeholders were grouped into four so-called social groups: timber producers, reindeer herders, recreationists, and environmentalists. All the forest-owning companies and the municipality were included in the group of timber producers, resulting in five representatives, while there was only one person in the reindeer herders' group (the representative of the reindeer husbandry district of the area). The environmentalists were represented by two people from nongovernmental organizations and one person each from the municipality and the County Board. The recreation group was represented by 14 people.

In the next step, criteria for the four social groups were identified in semistructured interviews with stakeholders. Stakeholders also identified specific areas important to them and explained what activities the areas were used for and the forest management they wished to see in these areas. Existing forest data were combined with information from interviews to create a map in which the urban forest was divided into zones of different management classes. Three alternative strategic forest plans were produced based on the zonal map. The stakeholders stated their preferences individually by the AHP in inquiry forms and ranks of alternatives and consistency ratios were determined for each stakeholder. Rankings of alternatives were aggregated; first, for each social group using the arithmetic mean, and then an overall aggregated ranking was calculated from the group rankings using the weighted arithmetic mean (Tab. 3). Consistency ratios (CR), a measure of the consistency of the individual judgments, were also calculated.

Table 3. *Weights for the social groups, weights for alternatives of each social group, and the aggregated weights for alternatives obtained by weighed arithmetic mean*

	Timber producers	Environ- mentalists	Recrea- tionists	Reindeer herders	Aggregated weights
Group weight	0.504	0.170	0.242	0.085	
Plan A	0.211	0.486	0.386	0.361	0.313
Plan B	0.305	0.071	0.132	0.074	0.204
Plan C	0.484	0.443	0.481	0.566	0.484

One of the alternatives, plan C, was ranked highly overall by all social groups. The inconsistency was generally high and the limit for acceptable inconsistency was set higher than normal, but still a number of stakeholder judgments had to be removed from the calculations of the final ranking because of high CR. The results were presented to and discussed by the steering group at a meeting. The results in general were accepted and approved, Plan C was adopted as a multiple-use forest management plan, and the steering group agreed to test a procedure for consultations in the planning of silvicultural treatments.

The participatory MCDA process in Lycksele was assessed against the five social goals proposed by Beierle and Cayford (2002): (i) incorporating public values into decisions, (ii) improving the substantive quality of decisions, (iii) resolving conflict among competing interests, (iv) building trust in institutions, and (v) educating and informing the public. The assessment indicated that the integration of MCDA into participatory planning is a promising approach for handling complex forest planning situations with multiple stakeholders and conflicting criteria. A strength was that the MCDA process incorporated stakeholder values in a structured way that ensured a certain degree of transparency of the decision making process. Furthermore, the MCDA process potentially increased the substantive quality of decisions by balancing interests against each other, thereby producing solutions of higher overall stakeholder satisfaction. The score for goals such as conflict resolution and education could have benefited from different management practices that would have intensified the interaction among stakeholders, for instance with more meetings with more direct public participation during a shorter period.

2.2 MCDA-based participatory forest planning with consideration to general and place-specific criteria (Paper II)

The objective of this study was to present an approach for including place-specific values in MCDA-based participatory forest planning in a process of three steps: (i) identification of different kinds of stakeholder values, (ii) definition of zones based on place-specific spatial values and other geographical information, and (iii) creation of an objective hierarchy consisting of nonspatial and non place-specific spatial criteria. Thus, this study was focused on stakeholder values and how these values may be incorporated into the forest planning process. The Lycksele case study described in Paper I was used to illustrate the approach in practice.

The values held by stakeholders were used as the starting point for the study rather than formalized criteria. A terminology where stakeholder values are subdivided into *nonspatial values* and *spatial values* was used (Fig. 6).

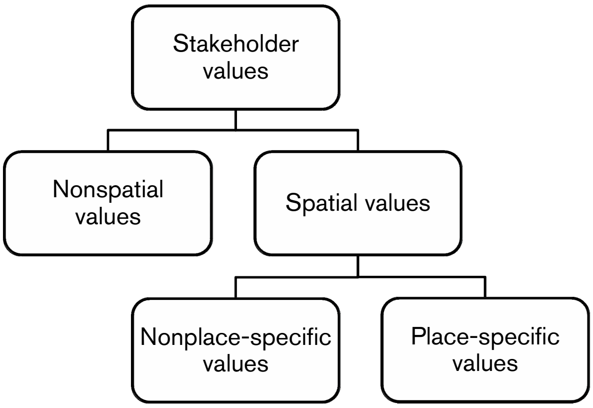

Figure 6. A schematic view of different types of values which stakeholders may want to express in a participatory forest planning process.

Nonspatial values can be expressed as the type of criteria commonly defined for MCDA and can be measured without using any spatial analysis, e.g., "Area of old-growth forest". Spatial values, in turn, can be divided into *non place-specific spatial values* and *place-specific spatial values*. Non place-specific spatial values can also be expressed as conventional MCDA criteria, but spatial analysis is needed to measure the performance of this type of criteria; for instance, some kind of measure describing a pattern in the landscape may be used. "Fragmentation of old-growth forest" and "Area of habitat for species X" are criteria of this type. Place-specific spatial values concern specific areas that are important because of their location, often in combination with certain structures or properties of the forest. The areas concerned are not interchangeable; i.e. the loss of one area cannot be fully compensated for by preserving another area. A place-specific criterion could be expressed as, e.g., "Preserve stand no. 5".

In a first step, stakeholder values were identified in semistructured interviews with questions about activities of the stakeholders and their views on the forest and forest management. Stakeholders were given maps on which they could mark areas of interest to them and explain why they were important, how they were used, and what kind of forest management would support their use.

In a second step, the place-specific spatial values were included through maps showing the areas of interest to the stakeholders of the recreation, environmentalist, and reindeer herding groups created from the interview maps. These thematic maps and a map showing the desired management class were presented for discussion in a meeting with the stakeholders. Next, a zonal map with the planning area divided into four zones was produced (Fig. 7). This map was created from the thematic maps and other geographical information. GIS analysis tools were used for identifying the preliminary outlines of the zones, but no formal numerical analysis was used. The zones were based on the type of silvicultural management that should be applied in each zone. The four zones were: (i) a zone with no commercial management, (ii) a zone with no clear-cutting, (iii) a zone with enhanced consideration for objectives other than timber production, and (iv) a zone with standard forest management. This zonal map was to be used as the basis for the creation of forest plan alternatives in a subsequent process.

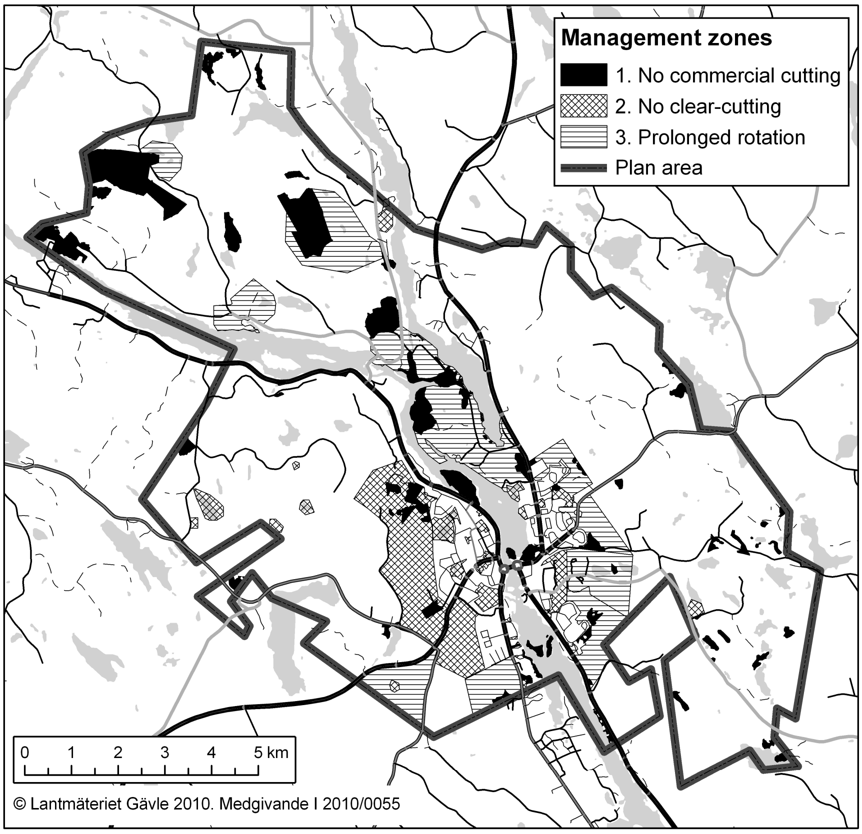

Figure 7. The zonal map that was created in the process in Lycksele based on place-specific values, in which the zones indicate the type of silvicultural management that should be applied to the forest.

In a third step, the nonspatial and non place-specific spatial values were formulated as criteria and used to build an objective hierarchy describing the decision situation. The hierarchies and the maps were presented to the stakeholders for discussion at a meeting, and minor changes were made to the hierarchies according to opinions expressed at the meeting. One objective hierarchy, containing nonspatial and non place-specific criteria, was produced for each of the four social groups. The common hierarchy was constructed by joining the four social groups under the overall objective "Overall utility" (Fig. 8). Environmentalists, recreationists, and reindeer herders had several criteria in common, whereas timber producers expressed a divergent set of criteria.

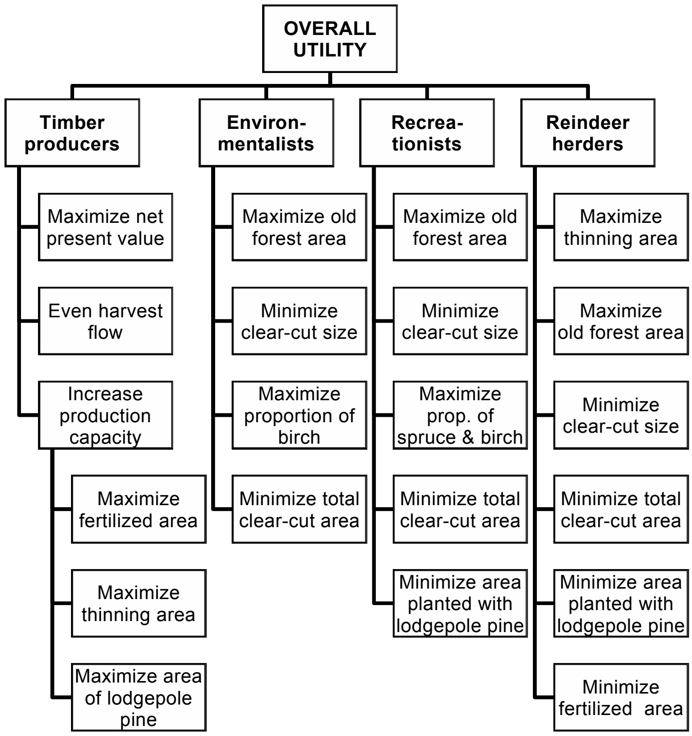

Figure 8. The objective hierarchy consisting of criteria formulated from the nonspatial values expressed by stakeholders in the Lycksele process.

The use of maps during the interviews supported the process of identifying values. Most stakeholders used the maps for marking areas, especially the recreationists, although the environmentalists and, to some extent, the reindeer herder, also expressed place-specific values by means of the maps. The forest company representatives, however, mostly talked in forest-wide terms. With a few exceptions, the approach seemed to work well; only a few stakeholders seemed unsure because they were not accustomed to using maps or because the scale or general layout of the maps was novel to them. For the majority of stakeholders, explaining how specific areas were used and the kind of management they wished to see in these areas was not a problem. That the management classes were predefined might have been a limitation for the stakeholders, but from a practical perspective it was necessary to have a few well-defined management classes that could be modeled when generating treatment schedules for the alternatives later on in the process. The study indicates that methods for capturing and incurporating place-specific values in participatory forest planning processes should be developed and tested further.

2.3 Aggregation of preferences in participatory forest planning with multiple criteria: an application to the urban forest in Lycksele, Sweden (Paper III)

This study focused on the part of the participatory MCDM process in which individual stakeholder preferences are aggregated into a collective preference. An EGP approach based on the determination of cardinal compromise consensus was applied to stakeholder preference data from the Lycksele case study and 12 alternative forest plans generated for this study. The aims of this study were to: (i) adapt the aggregation method proposed by González-Pachón and Romero (2007) to the character of the participatory forest planning process in Lycksele; (ii) explore possible consensus solutions for choice of forest management plan; and (iii) evaluate the usefulness of the aggregation method in participatory forest planning problems.

Goal programming (GP) deals with problems where target levels can be assigned to the attributes and non-achievement of the corresponding goals is minimized. How this non-achievement is measured depends on the specific GP approach that is used. Two common GP approaches are Archimedean (or weighted) GP and MINMAX (or Chebyshev). Archimedean GP can be interpreted as the maximization of a separable and additive utility function, which means that the overall utility is maximized and the solution obtained is the best from the point of view of the majority. MINMAX GP, on the other hand, implies the optimization of a utility function where the maximum deviation is minimized, which means that the solution obtained is the best from the point of view of the minority or the "worst-off individual" (Diaz-Balteiro & Romero, 2001). The EGP method combines the Archimedean and MINMAX formulations, and makes it possible to find compromise solutions between the two models. The core of the EGP models is a user-defined control parameter (λ, μ), which regulates the trade-off between the point of view of the majority (λ or $\mu = 1$) and the point of view of the minority or the worst-off individual (λ or $\mu = 0$). The control parameter λ is used in the first step of the approach and μ in the last step, but they serve a similar purpose.

The aggregation approach applied in this study is based on stakeholder preferences obtained through pairwise comparisons, e.g. by using AHP, which may be arranged in pairwise comparison matrices. The pairwise comparison matrices from the Lycksele case study described in Paper I were the starting point for a procedure adapted to the Lycksele case, consisting of four steps: (i) from the pairwise comparison matrices, a consensus matrix was obtained for each social group, (ii) from this matrix, the group weights for the criteria were derived, (iii) by using the group weights, the respective forest plans were evaluated in order to establish the group rankings of the alternative forest plans, and (iv) from the group rankings, the final aggregated or social rankings were obtained (Fig. 9). In steps 1 and 4 of the aggregation approach applied to the Lycksele case, EGP models were applied to find compromise solutions, and in step 2 an ordinary GP model was used for determining criteria weights.

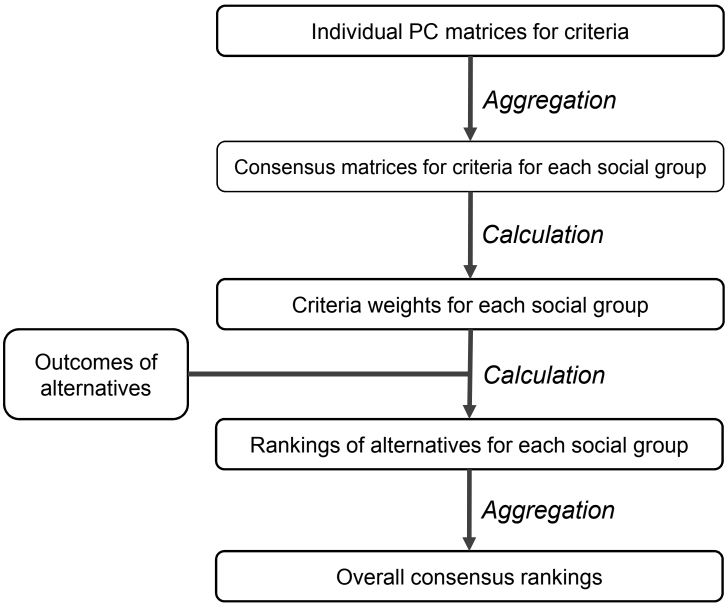

Figure 9. Overview of the EGP aggregation procedure; boxes represent inputs and outputs of data, and arrows represent the processing of data. (PC = pairwise comparison)

In the first step of the Lycksele case, the pairwise comparison matrices with preferences for the criteria of the individual stakeholders were aggregated using an EGP model in order to establish consensus matrices for each of the four social groups. The result was that three nondominated solutions for consensus matrices were found for the timber producers, two were found for the environmentalist group, and three for the recreationist group. Since the reindeer herders' group had only one member, no consensus matrix had to be produced for this group.

In the second step, a GP model was used to determine criteria weights from the consensus matrices for each social group. For the environmentalist group, the two consensus matrices produced the same vector of priority weights. However, from the consensus matrices for the timber producers, two different vectors of weights were derived; this was also the case for the recreationist group. For $\lambda = 1$, the best solution from the perspective of the majority is found because the overall disagreement is minimized. On the other hand, with $\lambda = 0$, the disagreement of the most displaced individual with respect to the consensus solution is minimized. In this situation, we chose to use the weights that correspond to the best solution for the majority in the next step, because it was the preferences of individuals belonging to the same social group with similar interests that were aggregated.

In the third step, two kinds of input were needed. First, there were the criteria weights for each social group obtained in the previous step. Second, the outcomes, or attribute values, of the 12 forest plan alternatives were needed. The outcomes were normalized to values between 0 and 1 so that they could be compared on a common scale. The normalized outcomes are multiplied by the corresponding criteria weights. Two different rankings of the alternatives are then obtained for each social group by applying two opposite perspectives: (i) maximization of the weighted average of the outcomes, and (ii) minimization of the most deviating result. This corresponds to the majority and the minority perspectives, respectively, of the control parameter (λ, μ).

In the last step, the rankings of the social groups were aggregated using an EGP model to determine consensus solutions for the choice of the best forest management plan from a collective perspective. The EGP model was applied first to the set of rankings derived from perspective 1 in the previous step and then to the set of rankings derived from perspective 2. The first solution represented the "best" consensus ranking from the point of view of the majority, while the second solution represented the "best" consensus ranking from the point of view of the minority (i.e. the group with perceptions most displaced with respect to the consensus obtained). Different weights were also attached to the social groups to produce solutions with varying balances between the social groups.

The rankings of alternatives for each social group displayed a distinctive pattern; the rankings of timber producers were markedly different from the rankings of the other social groups. In contrast, the rankings for environmentalists, recreationists and reindeer herders were very similar or even identical in some cases. Thus, when a majority perspective was applied, the weights of the different stakeholders strongly affected the solutions for a consensus ranking. Hence, if a compromise solution is desired, only the solutions where the two opposing sides, i.e., timber producers and environmentalists/recreationists/ reindeer herders, have equal weights are of interest. When a minority perspective was applied and the stakeholder weights were varied, a number of different consensus rankings were produced.

This approach made it possible to aggregate preferences of different stakeholders and to produce a range of different solutions. Furthermore, certain values of the control parameters and the distance metric generated solutions that seemed promising to present in a participatory situation where stakeholders have very differing preferences.

2.4 An experimental study of approaches for aggregating preferences in participatory forest planning (Paper IV)

The aim of this study was to compare three approaches for the aggregation of stakeholders' preferences in a participatory MCDA process: EGP, WAMM, and GMM. A group preference approach was used as a reference for comparison.

The study was based on a role playing exercise, in which masters students at the Swedish University of Agricultural Sciences acted as stakeholders in a participatory forest planning situation. An objective hierarchy and five alternative forest management plans prepared in advance were presented to the students, who were asked to give their preferences for the criteria and the alternatives using the AHP pairwise comparison procedure. The students were asked to make the pairwise comparisons individually. After giving their individual preferences, the group collectively made pairwise comparisons to determine the relative importance of each stakeholder. The individual preferences were then aggregated into a collective preference, ranking the alternatives, by using the three different approaches EGP, WAMM, and GMM. In the group using the group preference approach the students made all pairwise comparisons together in a group discussion.

With WAMM, overall weights for the alternatives were calculated for each individual and then a consensus ranking was determined by calculating the weighted arithmetic mean for the weight of each alternative, using the previously determined weights of influence for the stakeholders. With GMM, the geometric mean of the judgments of all stakeholders for each element in the pairwise comparison matrices was calculated. The result was one matrix with aggregated preferences for the criteria and a number of matrices with aggregated preferences for the alternatives in terms of each criterion. Weights for criteria and alternatives were then determined from these matrices and overall weights for the alternatives could be calculated and a consensus ranking obtained. The EGP approach contained three steps: (i) criteria weights were established from the preference matrices using an

EGP model, (ii) the individual preferences in the form of criteria weights were aggregated into a common preference using a second EGP model, and (iii) the alternatives were evaluated for each criterion using a value function. The criteria weights were then combined with the weights for the different alternatives produced by the value functions, resulting in overall weights and a consensus ranking of alternatives. Figure 10 gives an overview of the aggregation methods.

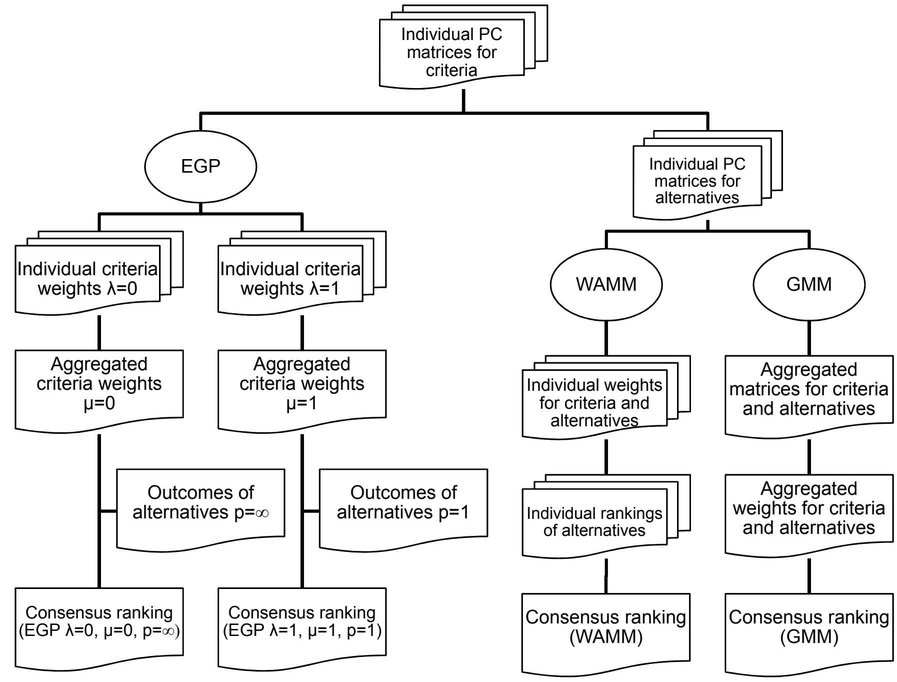

Figure 10. Overview of the inputs and outputs of the different approaches for the aggregation of preferences. Ovals indicate methods, multiple-document icons indicate individual preferences of multiple stakeholders, and single-document icons indicate preferences that are aggregated for or common to all stakeholders. (PC = pairwise comparison)

Plan C, the "recreation" alternative, obtained the highest rank in all but two of the consensus rankings (Tab. 4). The reason for this seemed to be that the tourism entrepreneur and the representative for sport and outdoor life, for both of whom recreation was their main interest, were given large weights of influence (0.31 and 0.19). Plans D and E, the "mixed" alternatives, attained the highest rank in EGP with a minority perspective ($\lambda = 0$, $\mu = 0$, and $p = \infty$). This illustrates the balancing effect of the minority perspective because plan D was in fact a compromise solution between timber production, biodiversity and, to some extent, recreation while plan E was a compromise between timber production, recreation and, to some extent, biodiversity. The results from the group preference approach were that plans C and D tied for first place and plan A was a very close third.

Table 4. *Consensus rankings of the alternatives A–E obtained using the different methods. The rankings range from 1 to 5, where 1 is the highest rank and 5 is the lowest rank. Values within parentheses are the weights for each alternative for the group preference approach, the GMM, and WAMM (the larger the value, the higher ranked is the alternative) and the displacement from the ideal for EGP (the lower the value, the higher ranked is the alternative); the rankings are determined from the values in parentheses*

Alternative		A	B	C	D	E
Group preference approach		3 (0.22)	4 (0.17)	1 (0.23)	1 (0.23)	5 (0.15)
GMM		5 (0.12)	2 (0.19)	1 (0.34)	3 (0.18)	4 (0.17)
WAMM	Different stakeholder weights	3 (0.18)	5 (0.15)	1 (0.30)	2 (0.22)	4 (0.16)
	Equal stakeholder weights	5 (0.15)	3 (0.17)	1 (0.31)	2 (0.21)	3 (0.17)
EGP	Different stakeholder weights					
	$\lambda = 1, \mu = 1, p = 1$	2 (0.58)	5 (0.81)	1 (0.36)	4 (0.60)	2 (0.58)
	$\lambda = 0, \mu = 0, p = \infty$	2 (0.19)	5 (0.38)	4 (0.33)	1 (0.13)	3 (0.30)
	Equal stakeholder weights					
	$\lambda = 1, \mu = 1, p = 1$	4 (0.66)	5 (0.82)	1 (0.28)	3 (0.63)	2 (0.54)
	$\lambda = 0, \mu = 0, p = \infty$	4 (0.33)	4 (0.33)	2 (0.22)	2 (0.22)	1 (0.20)

The minority perspective of EGP seemed to be useful for finding balanced consensus solutions that are not determined exclusively by the weight of influence assigned to each stakeholder. This property could be desirable in politically sensitive situations or situations where stakeholders have very diverging values.

The approaches have different properties and result in different rankings, thus the main conclusions are that the choice of aggregation approach should depend on the situation and be accounted for to the stakeholders. Moreover, if aggregation methods are used in participatory planning, they should be used as tools for exploring and increasing knowledge about the issue rather than as methods that produce “the optimal solution”.

3 Discussion and Conclusions

The main objective of the studies this thesis is based upon was to investigate approaches for integrating MCDA into a participatory forest planning process by assessing the integrated process as a whole and, specifically, by focusing on how stakeholder values are included in the process and how individual preferences are aggregated into a common preference. The case studies show that MCDA might contribute to a successful participatory planning process. However, even if this seems to be a viable approach, some issues concerning the practical application of, and research into, the integrated process need to be discussed.

3.1 The integrated process

In Paper I, the Lycksele case study, stakeholder values were identified in individual interviews. The advantage of this approach is that the stakeholders initially have to think through their own values and have an equal opportunity to express their opinions, which may not always be the case in a group discussion. The disadvantage is that the stakeholders will not get to know other stakeholders' perspectives nor be able to develop a shared understanding of the problem if they do not meet.

In the problem structuring phase, an approach that would allow stakeholders to express place-specific values (Paper II) was used. Paper maps were used in the interviews and the stakeholders had the opportunity to use the maps for drawing and explaining place-specific values. Most stakeholders used the maps for marking important areas, except for the forest company representatives who mostly spoke in more general terms. With a few exceptions the approach seemed to work well; only a few stakeholders seemed unsure about using the maps since they were not accustomed to maps or the scale or general layout of the maps was novel to them.

Place-specific values were then incorporated into the alternatives in a two-step procedure (Papers I and II). First, the maps drawn by stakeholders in the interviews formed the basis for constructing a map with zones of different forest management. The zonal map then formed the basis for defining treatment schedules when three different alternative plans were generated. The problem of including place-specific values is related both to the kind of decision problem we face and how the alternatives are formulated. The zonal map proved to be as interesting an outcome to the stakeholders as the plans (Paper I), indicating that place-specific values were important to stakeholders. It seems that methods for identifying place-specific values are needed in order to incorporate local and traditional knowledge into the planning. An MCDA-based process where only general forest-wide objectives are considered may be more suitable on a policy level where stakeholders are national or regional interest groups and general public. However, the place-specific stakeholder values might have been better accounted for by producing and evaluating several alternative zonal maps before the alternatives were generated. For instance, Zucca *et al.* (2008) recently presented an approach for this in a case of site selection for a local park in northern Italy that could be adapted to forest planning.

AHP was used for eliciting the preferences of the stakeholders (Paper I). Our experience from the Lycksele case is that AHP could be used in a participatory forest planning process, but the high inconsistency in judgments of some stakeholders indicates that certain issues have to be considered in the design of the process. Firstly, stakeholders stated their preferences individually through a written form as proposed by Saaty (1990), but we conclude that support is needed when stakeholders express their preferences, including explaining the method and answering questions. It may also be necessary to repeat certain comparisons if the inconsistency is high to try to ensure that preferences are not misleading. Numerical methods for improving consistency in preferences have been developed (e.g., Cao *et al.*, 2008; Xu & Wei, 1999), but since this involves modifying the stakeholders' judgments such methods may be regarded as manipulation and are not appropriate to use in a participatory planning situation. Furthermore, preferences modified for consistency may not actually be closer to the "true" preferences of the stakeholders than the original, inconsistent preferences (Linares, 2009). Good support in the judgment process seems to be a better solution.

It seems likely that a factor contributing to the high inconsistency reported in Paper I was the burdensome procedure of making many comparisons (Ananda, 2007; Kangas & Kangas, 2005). Even though six was the maximum number of elements compared at any level and only three alternatives were compared for each attribute, between 18 and 33 comparisons still had to be made by each stakeholder.

Approaches for reducing the number of comparisons, such as regression techniques for estimating preferences and hybrid techniques, combining AHP with other MCDA techniques, have been developed (Kangas & Kangas, 2005). These approaches could be useful in a participatory process, provided that they are not perceived as confusing or even manipulative by stakeholders. In the Lycksele case study described in Paper I, the participatory process involved stakeholder representatives rather than direct participation by the public. In a process with stakeholder representatives the participants may already be familiar with the issue, as in the Lycksele case, and repeated meetings can be used for learning more about the issue and the AHP method. In a process with direct public participation, where the time and commitment of stakeholders is often limited, less demanding methods than AHP may be more appropriate (Kangas & Kangas, 2005).

In work on the case study reported in Paper I, the aggregation of individual preferences into a common preference stood out as a very decisive part of the participatory MCDA process as it is the mechanism that ultimately sets the influence of each stakeholder over the final outcome. In Paper I, a weighted arithmetic mean was used for aggregating the preferences of the social groups into a common preference. An average of some kind has been the most frequently used aggregation method in participatory MCDA forest planning case studies (see, e.g., Ananda, 2007; Pykäläinen *et al.*, 2007; Kangas *et al.*, 2001a; Pykäläinen *et al.*, 1999; Kangas *et al.*, 1996; Kangas, 1994), with weights commonly decided by the decision maker in charge of the process, as in Paper I. However, the implications of this procedure for the participatory process have not been discussed to any great extent in the forest planning case studies. The EGP approach, tested on data from Lycksele in Paper III, brings the democratic aspect of minority versus majority perspective into the aggregation problem. Since with EGP the weights assigned to the stakeholders are not the exclusively determining factor, this approach for aggregation seems particularly relevant in a participatory context.

In Paper IV a tentative comparison is made between the EGP and the more established aggregation approaches based on geometric and arithmetic means. In the study, the aggregation approaches have different properties and result in different outcomes; thus, the choice of aggregation approach should be justified in order to avoid being arbitrary or manipulative. The main conclusion in Paper IV is that the aggregation approaches have different properties and provide different rankings. That the approaches produce different results need not be a problem; no result should be regarded as more valid than another and the differences can be seen as consequences of the properties of the different methods (cf. Kangas *et al.*, 2001b). Moreover, if MCDA and aggregation methods are used in participatory planning, these methods should be presented and used in such a way that it is clear that they are tools for exploring and increasing knowledge about the issue rather than infallible methods that produce "the optimal solution"; that is, a process-oriented rather than an outcome-oriented perspective have to be applied (Mendoza & Martins, 2006). The aggregation should be supplemented by a sensitivity analysis and used as a basis for discussion about the preferences of the stakeholders and how different levels of influence may affect the total ranking of alternatives. The choice of aggregation approach should be adapted to the situation at hand and, furthermore, should be accounted for and explained to the stakeholders. This may prove to be a considerable pedagogical problem; though it may not be possible to explain the aggregation method in full detail, at least the underlying logic should make sense to stakeholders. For instance, with the EGP approach it is possible to choose a democratic perspective and balance minority and majority perspectives against each other to find compromise solutions; but on the other hand, the calculations for this approach may be more complex and more difficult to explain to stakeholders. Thus, the type of decision problem and stakeholders involved should guide the choice of aggregation approach.

In the case study described in Paper I, we used a problem-structuring approach; a lot of time and effort was put into the stakeholder analysis, the identification of criteria and generation of alternatives. In addition it was not the final outcome in the form of a plan, but the process in the form of new knowledge and a new consultation procedure that proved to be the most important result of the project from the stakeholder perspective. The process described in Paper I would have been improved by more focus on the communicative and participatory aspects of the process. For instance, more interaction between stakeholders would have meant better opportunities for social learning and conflict resolution. Clearly, in research on the integration of MCDA into participatory planning, an interdisciplinary approach is needed. In a forest planning process, knowledge about planning models and specialized software is needed to generate forest plans. Knowledge about MCDA and the properties of different techniques is also needed, as well as process leading skills. In most cases, a team of specialists with varying expertise is probably the most appropriate solution to the interdisciplinary challenge. A participatory forest planning process with MCDA is thus very resource-demanding; from a practical perspective, a forest owner who wants to carry out such a process will probably need to hire specialized consultants.

To summarize, what was gained by using MCDA and participatory planning in the Lycksele planning process? The answers to this question can be approached by examining the results from the Lycksele case study from different perspectives. From an instrumental point of view, the process in Lycksele was successful in producing a plan and procedures for consultation that will be implemented in forest planning as a tool that could prevent costly conflicts. From a substantive point of view the process in Lycksele produced new knowledge as a basis for planning, partly through the use of MCDA. Hopefully, this knowledge will contribute to more efficient planning from a societal perspective since not only income from industrial forestry, but also commodities such as biodiversity and recreational opportunities are considered in the forest plan produced. Further, the process generated understanding about planning problems, which could lead to better coordination between different owners in forest planning, e.g. clear-cutting of adjacent areas at the same time may be avoided. The Lycksele process was less successful from a normative point of view because of the protracted nature of the process with too little interaction between stakeholders. Social learning did not really take place and relations between the stakeholders were not much changed as a result of the process, with the exception of the members of the steering group who met and discussed repeatedly during the process. In this case, the use of MCDA did not assist social learning but rather made it possible to produce and choose a plan without much interaction between stakeholders.

3.2 Research methodology

Case study is the most common form for research on MCDA in participatory forest planning. As with any other research strategy, the design and analysis of results in a case study have to be carefully planned to be able to answer the research questions (Benbasat *et al.*, 1987; Yin, 1981). This often involves using qualitative methods rather than hypothesis testing and statistics. However, in most case studies on MCDA in participatory processes discussions are focused on the numerical results produced by MCDA and the properties of the MCDA methods, while little or no attention is paid to the research strategy. This indicates a need for interdisciplinary research, including both natural and social scientists, in case studies of MCDA.

Validity, reliability and objectivity may be assessed in qualitative as well as quantitative research, although by different approaches which must be considered in the research strategy. Since qualitative research is based on a constructivist rather than a positivist view of knowledge, these criteria may be interpreted and applied somewhat differently than in quantitative research, and because of that other terms are often used (Tab. 5).

Table 5. *Criteria for assessing research according to quantitative and qualitative research traditions (Dahlgren et al., 2007; Lincoln & Guba, 1985)*

Question asked	Issue	Qualitative criteria	Quantitative criteria
Have we really measured what we set out to measure?	Truth value	Credibility	Internal validity
How applicable are our results to other subjects and other contexts?	Applicability	Transferability	External validity
Would our findings be repeated if our research were replicated in the same context with the same subjects?	Consistency	Dependability	Reliability
To what extent are our findings affected by personal interests and biases?	Neutrality	Confirmability	Objectivity

The credibility of a case study depends on how well the researcher is able to capture the diverse subjective realities of the study subjects, and if the study subjects recognize and accept the researcher's representation of their realities (Lincoln & Guba, 1985). One approach for increasing the credibility of a study is to use triangulation, which means that findings and conclusions are based on multiple sources of evidence (Yin, 1994). There are different types of triangulation; i.e. triangulation (i) of data sources, (ii) among different investigators, (iii) of theory (different perspectives on the same data), and (iv) of methods (Yin, 1994; Lincoln & Guba, 1985). In the study of Paper I, the assessment of the process is based on the numerical results produced by MCDA and on the authors' observation. The credibility and depth of the study might for instance have been improved by letting stakeholders evaluate the participatory process, which would have been a form of data triangulation. Investigator triangulation could also have been used by having an independent observer present during the meetings.

From a natural sciences perspective, a basic criticism of qualitative research is that this type of research cannot be transferred or generalized to other studies in the same way as quantitative research. However, if the framework of ideas and the methodology used are clearly declared, including the role and perspective of the researchers, the research process is recoverable, i.e. results can be understood and used by others (Checkland & Holwell, 1998). Basically, the phenomenon under study cannot be separated from its context; rather, the context affects the phenomenon and is thus an important part of the study. Some qualitative researchers take the view that the transferability of findings made in one context to a new context should be judged by someone familiar with the new context rather than the researcher that produced the original findings (Lincoln & Guba, 1985). In the work presented in this thesis data from a single case were gathered, and the possibility of generalizing from this study or transferring results to other cases may be limited. However, the Lycksele case is characterized by the urban forest and a multiple owner situation, and in this respect it is relevant to situations in which the approach of combining MCDA and participatory forest planning might be useful in a Swedish context. Another crucial reason for choosing the Lycksele case was that the municipality and the other forest owners were interested in having a participatory process.

Obviously, a case study can never be repeated exactly and, consequently, the results cannot be reproduced by even by the same researcher. Thus, other ways of assessing the dependability must be used. For instance, a well documented research process could make it possible for an outsider to audit the research; the documentation should contain not only data but also show how decisions were made and conclusions were reached, and include a case study protocol or plan that provides an overview of the project and clarifies purpose and research questions (Yin, 1994; Lincoln & Guba, 1985). This was partly done in the Lycksele case; however, the dependability might have been improved if the process had been more firmly based on a qualitative research approach.

In many cases the researchers have also been part of the process by acting as analysts or process leaders. Thus, inevitably, the researchers have influenced the process and, possibly, the outcome of the process; however, the implications of this are hardly ever discussed, even though it affects the confirmability of the study. In the Lycksele case, for instance, the roles of my colleagues and I were primarily that of researchers, but we were also consultants hired by the municipality as process leaders in a project sponsored by the forest-owning companies. The predefined aim of the project was to produce a multiple-use forest management plan to be used as a planning tool by the municipality and the other forest owners to prevent conflict. Taking into account that this has almost certainly affected our view of the project and our way of leading the process should be advantageous rather than disadvantageous from a research perspective in making explicit the framing of the decision problem (see, e.g., Stirling, 2006).

In a process such as the Lycksele case, research could be regarded as a form of action research, in line with Checkland and Holwell's (1998) definition of action research from a systems thinking perspective as a cyclical process where *"the researcher enters a real-world situation and aims both to improve it and to acquire knowledge"*. The researcher is a part of the system under study and with an action research approach the researcher acknowledges and discusses the effect of this rather than trying to justify the objectivity of the study. An action-oriented approach may be needed when addressing research questions concerning MCDA in participatory forest planning. For instance, social learning is essentially a process of change, and action research can be suitable for exploring questions relating to how MCDA affects communication and social learning in the process. In theory MCDA is a tool for eliciting ready-formed preferences from stakeholders, but in reality it may help stakeholders to explore and express undefined values or even to think about, develop and change certain values. From this point of view, experimental studies like the one presented in Paper IV may not be able to tell us very much about the usefulness of the integrated approach in real situations. Possibly, an action research approach could provide valuable insights for real-world applications of MCDA and participatory planning.

3.3 Conclusions for Swedish forest planning

The Lycksele case shows that the combination of MCDA and participatory planning is an approach that could be useful in a Swedish forest planning context under certain conditions. Primarily, the integrated process is a tool for long-term forest planning and may be used to improve understanding and relations between stakeholders in order to prevent conflict and to include multiple perspectives in order to improve the planning from a societal point of view.

In situations where latent conflicts of interest have already flared up into a conflict, in which communication is no longer constructive and stakeholders distrust each other, a conflict management process is needed. If communication and trust between parties can be improved through conflict management, then the integrated process could possibly be used to prevent future conflict (Kangas *et al.*, 1996). Furthermore, a common type of Swedish forest conflict seems to be caused by silvicultural treatment at a stand level, i.e. cases when treatments such as clear-cutting or thinning are applied to specific stands (Eriksson *et al.*, 2010). Since these conflicts occur at an operational level, the integrated process presented in this thesis should be modified. However, using the integrated process in long-term planning may help prevent conflict at stand level.

Who would then use the integrated process in a Swedish context? First of all the municipalities. As the municipality forests are public forests, the integrated process could be a very useful tool for creating long-term multiple-use plans for the municipality forests and thereby increase the transparency and possibly the efficiency of the decision-making.

Another owner category for which the integrated process may be useful is the forest companies, including the state-owned Sveaskog. Companies do not have the same obvious interest and obligation to include public values as the municipalities, but companies may also benefit from using the integrated process. The integrated process can assist in meeting certification standard criteria to consider social values in forest management and by using the integrated process companies may improve relations with stakeholders and potentially avoid some costly conflicts. Companies could use the integrated process for incorporating social values into long-term planning in very much the same way as ecological landscape planning has been integrated into the planning process. In the Lycksele case, the participatory planning process was carried out independently of the planning processes of the companies. A consequence may be that the multiple-use plan will not be implemented as it is. However, the zonal map resulting from the participatory process could prove more convenient to use as a planning tool than the actual plan. Thus, planning with the integrated process should be coordinated with company planning processes, which may be easier to achieve if there is only one owner of the forest in the planning area.

Although the integrated process may be useful to individual private forest owners for the same reasons as for companies, it is doubtful whether they would ever use it to any great extent. Some forest owners with large holdings, such as estates with income from tourism, may be interested in using the integrated process as a planning tool. For instance, even though the forest owner is not preparing a long-term plan, the thematic maps described in Paper II could provide private forest owners with information about social impacts of their forest management. However, even though individual private forest owners own 50 % of the Swedish forest and a large proportion of the urban forest, most individual private forest owners will lack resources and interest in starting a participatory process. An exception could be if a landscape regulation, such as the water directive of the EU, demanded cooperation between forest owners.

Because of the strong status conferred by ownership, the integrated process would, in most cases, be a top-down approach initiated by the owner or the authorities. A major challenge would then be to motivate stakeholders to participate and to create trust in the process. The aim of using the integrated process in forest planning is to prevent conflict by including stakeholders in the planning process, but paradoxically, people may take an active interest only when their values are imminently threatened; in these situations conflict may be unavoidable. Studies on how participation in forest planning is perceived by stakeholders (e.g., Kangas *et al.*, 2010; Saarikoski *et al.*, 2010; Cheng & Mattor, 2006) report that uncertainty about the extent of influence of the stakeholders and the limitations of the process may be a problem, as well as uncertainty as to how the values of stakeholders will be incorporated into the decision making. To be involved in a participatory process may be demanding and entail responsibilities, and many stakeholders, e.g. local people and lay people, may not be prepared to commit to a process where the mandate and extent of influence is unclear (Hamersley Chambers & Beckley, 2003). The use of the participatory process merely as a medium for exchanging information with the public may contribute to the problem and does not realize the full potential of participation (Saarikoski *et al.*, 2010; Leskinen, 2004). Possibly, MCDA could assist in making the impact of stakeholder participation on decisions more transparent and, with a problem-structuring approach, could be a tool for generating new ideas and solutions in the process, as a way of making participation more attractive. This demand however that process and methods are carefully adapted to the situation and the type of stakeholders involved.

3.4 Future research

Focus has been shifting in MCDA from a problem-solving approach to a problem-structuring approach (Mendoza & Martins, 2006). In other words, there is a shift from substantive rationality to procedural rationality, from an outcome-oriented to a process-oriented view (Simon, 1976). Originally, MCDA was a tool created for finding the "best" solution, given the decision maker's preferences. Nowadays when MCDA is used in participatory planning, the aims are often to describe and understand the decision making problem properly and learn about other stakeholders' perspectives. Thus, applied research needs to pay more attention to the communicative and deliberative aspects of a participatory MCDA process, rather than on technical properties and pure numerical outcomes (Proctor, 2005; Kangas *et al.*, 2001b; Bogetoft & Pruzan, 1997). As pointed out by Stirling (2006), using MCDA in an outcome-oriented rather than a process-oriented way means that we risk "closing down" rather than "opening up" the planning process to the influence of stakeholders.

To use a process-oriented, problem-solving approach is resource-demanding, in terms of time and competence, and requires an inter-disciplinary method of working. From an applied point of view, inter-disciplinary teams of specialists from management science as well as natural sciences and social sciences may be required to plan and carry out an efficient and effective process. In this way a protracted process as in the Lycksele case may be avoided and opportunities for social learning may be increased. From the research point of view too, an interdisciplinary approach is needed; e.g. the use of MCDA requires knowledge about its methods, leading the process requires communicative skills, and knowledge of qualitative methods are needed in the evaluation of the process. An interdisciplinary research project requires research groups with different competences which must be carefully organized and coordinated.

From a methodological point of view, formal approaches for identifying and incorporating place-specific values into forest planning need to be developed. In addition, there is a need for approaches for generating appropriate forest plan alternatives, because although forest planning problems are mostly of a continuous character, the MCDA techniques used in participatory planning are approaches for choosing an alternative from a discrete set. Development of decision support systems supporting MCDA and spatial analysis would provide a powerful tool for participatory planning situations.

Further development of research on MCDA in participatory forest planning would include evaluation of the participatory processes and the role of MCDA in real-world case studies. However, to develop a general framework for evaluation to be applied to any case study is not feasible; rather, approaches for evaluation adapted to the decision-making context have to be tested (Stirling, 2006). Furthermore, the role of the researchers and the framing of the decision making problem should be considered in the evaluation.

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